NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
(Bioventing)

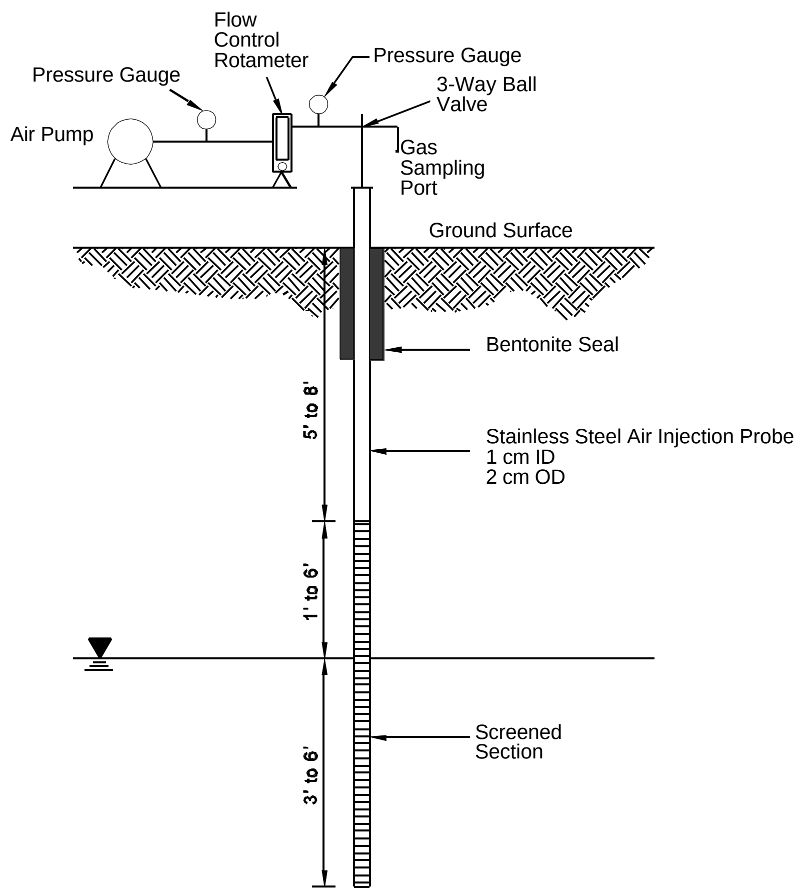
TECHNOLOGY DESCRIPTION:

Lack of oxygen in contaminated soil often limits aerobic microbial growth. The bioventing biological system treats contaminated soil in situ by injecting atmospheric air. This air provides a continuous oxygen source, which enhances the growth of microorganisms naturally present in the soil. Additives such as ozone or nutrients may be introduced to stimulate microbial growth.

Bioventing technology uses an air pump attached to one of a series of air injection probes (see figure below). The air pump operates at extremely low pressures, providing inflow of oxygen without significantly volatilizing soil contaminants. The treatment capacity depends on the number of injection probes, the size of the air pump, and site characteristics such as soil porosity.

WASTE APPLICABILITY:

Bioventing is typically used to treat soil contaminated by industrial processes and can treat any contamination subject to aerobic microbial degradation. Bioventing treats contaminants and combinations of contaminants with varying degrees of success.



Bioventing System

STATUS:

This technology was accepted into the SITE Demonstration Program in July 1991. The demonstration began in November 1992 at the Reilly Tar site in St. Louis Park, Minnesota. Soil at this site is contaminated with polynuclear aromatic hydrocarbons. The project will be completed in November 1997.

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PHYTOKINETICS, INC.
(Phytoremediation Process)

TECHNOLOGY DESCRIPTION:

Phytoremediation is the treatment of contaminated soils, sediments, and groundwater with higher plants. Several biological mechanisms are involved in phytoremediation. The plant's ability to enhance bacterial and fungal degradative processes is important in the treatment of soils. Plant-root exudates, which contain nutrients, metabolites, and enzymes, contribute to the stimulation of microbial activity. In the zone of soil closely associated with the plant root (rhizosphere), expanded populations of metabolically active microbes can biodegrade organic soil contaminants.

The application of phytoremediation involves characterizing the site and determining the proper planting strategy to maximize the interception and degradation of organic contaminants. Site monitoring ensures that the planting strategy is proceeding as planned. The following text discusses (1) using grasses to remediate surface soils contaminated with organic chemical wastes, and (2) planting dense rows of poplar trees to treat organic contaminants in the saturated groundwater zone.

Soil Remediation **-** Phytoremediation is best suited for surface soils contaminated with intermediate levels of organic contaminants. Preliminary soil phytotoxicity tests are conducted at a range of contaminant concentrations to select plants which are tolerant. The contaminants should be relatively nonleachable, and must be within the reach of plant roots. Greenhouse-scale treatability studies are often used to select appropriate plant species.

Grasses are frequently used because of their dense fibrous root systems. The selected species are planted, soil nutrients are added, and the plots are intensively cultivated. Plant shoots are cut during the growing season to maintain vegetative, as opposed to reproductive, growth. Based on the

Phytoremediation of Surface Soils

Phytoremediation of the Saturated Zone

types and concentrations of contaminants, several growing seasons may be required to meet the site's remedial goals.

Groundwater Remediation - The use of poplar trees for the treatment of groundwater relies in part on the tree's high rate of water use to create a hydraulic barrier. This technology requires the establishment of deep roots that use water from the saturated zone. Phytokinetics uses deep-rooted, water-loving trees such as poplars to intercept groundwater plumes and reduce contaminant levels. Poplars are often used because they are phreatophytic; that is, they have the ability to use water directly from the saturated zone.

A dense double or triple row of rapidly growing poplars is planted downgradient from the plume, perpendicular to the direction of groundwater flow. Special cultivation practices are use to induce deep root systems. The trees can create a zone of depression in the groundwater during the summer months because of their high rate of water use. Groundwater contaminants may tend to be stopped by the zone of depression, becoming adsorbed to soil particles in the aerobic rhizosphere of the trees. Reduced contaminant levels in the downgradient groundwater plume would result from the degradative processes described above.

WASTE APPLICABILITY:

Phytoremediation is used for soils, sediments, and groundwater containing intermediate levels of organic contaminants.

STATUS:

This technology was accepted into the SITE Demonstration Program in 1995. The demonstration will occur at the former Chevron Terminal #129-0350 site in Ogden, Utah. This demonstration will assess the ability of higher plants to reduce the concentration of petroleum hydrocarbons in near-surface soils, and to modify the groundwater gradient and reduce petroleum hydrocarbons in the saturated zone. Alfalfa and fescue plantings will be evaluated for soil remediation, while poplar and juniper trees will be investigated for their ability to treat the saturated groundwater zone.

The primary objectives of the demonstration are to determine whether (1) total petroleum hydrocarbon concentrations in the soil in plots planted with alfalfa and fescue will be reduced by 30 percent annually, and (2) an average annual 3-inch change in the groundwater elevation can be attributed to the trees. The demonstration is scheduled for the 1997 and 1998 growing seasons.

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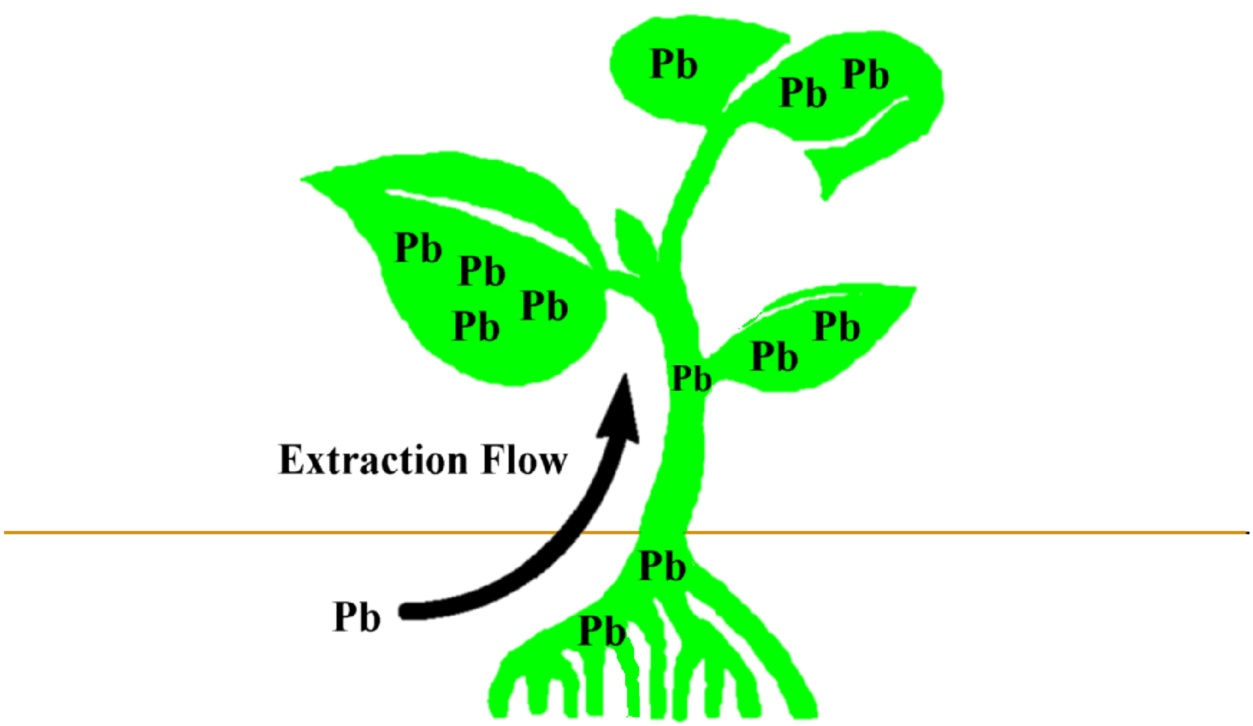
PHYTOTECH
(Phytoremediation Technology)

TECHNOLOGY DESCRIPTION:

Phytotech is an environmental biotechnology company that uses specially selected and engineered plants to treat soil and water contaminated with toxic metals such as lead and cadmium, as well as radionuclides. The treatment of soils or sediments with this technology is referred to as phytoextraction (see figure below).

Phytoextraction offers an efficient, cost-effective, and environmentally friendly way to clean up heavy metal contamination. Plants are grown in situ on contaminated soil and harvested after toxic metals accumulate in the plant tissues. The degree of accumulation varies with several factors, but can be as high as 2 percent of the plants' aboveground dry weight, leaving clean soil in place that meets or exceeds regulatory cleanup levels.

After accumulation in the plant tissues, the contaminant metal must be disposed of, but the amount of disposable biomass is a small fraction of the amount of soil treated. For example, excavating and landfilling a 10-acre site contaminated with 400 parts per million (ppm) lead to a depth of 1 foot requires handling roughly 20,000 tons of lead-contaminated soil. Phytoextraction of a typical 10-acre site to remove 400 ppm of lead from the top 1 foot would require disposal of around 500 tons of biomass - about 1/400 of the soil cleaned. In the example cited, six to eight crops would typically be needed, with three or four crops per growing season. Compared to traditional remedial technologies,



Phytoextraction

phytoextraction offers the following benefits:

- Lower cost
- Applicability to a broad range of metals
- Potential for recycling the metal-rich biomass
- Minimal environmental disturbance
- Minimization of secondary air- and water-borne wastes

WASTE APPLICABILITY:

Phytotech's phytoextraction technology can be used to clean soil or sediments contaminated with lead, cadmium, chromium, cesium/strontium and uranium. Phytoremediation of other metals such as arsenic, zinc, copper, and thorium is in the research stage.

STATUS:

Phytotech was accepted into the SITE Demonstration Program in 1996. Under the SITE Program, Phytotech is demonstrating its phytoremediation technology at a former metal-plating facility in Findlay, Ohio where soil is contaminated with heavy metals. The site has been prepared and characterized; the contaminant metals are chromium, cadmium, nickel, zinc and lead. Two crops were planted and harvested in late summer 1996. Phytotech has also conducted several successful field trials of its phytoextraction technology at other contaminated sites in the U.S. and abroad.

Phytotech has conducted several field demonstrations of its rhizofiltration technology for the removal of (1) cesium/strontium at Chernobyl, and (2) uranium from contaminated groundwater at a DOE site in Ashtabula, Ohio. At Chernobyl, sunflowers were shown to extract 95 percent of the radionuclides from a small pond within 10 days. At the Ashtabula site, Phytotech ran a 9-month pilot demonstration during which incoming water containing as much as 450 parts per billion (ppb) uranium was treated to 5 ppb or less of uranium.

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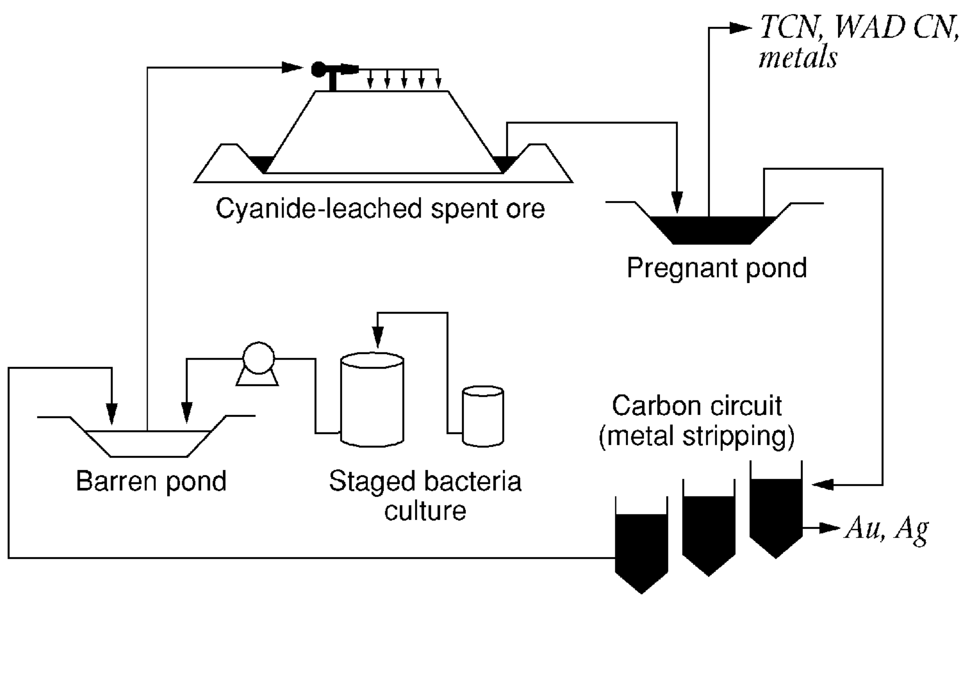
PINTAIL SYSTEMS, INC.
(Spent Ore Bioremediation Process)

TECHNOLOGY DESCRIPTION:

This technology uses microbial detoxification of cyanide in heap leach processes to reduce cyanide levels in spent ore and process solutions. The biotreatment populations of natural soil bacteria are grown to elevated concentrations, which are applied to spent ore by drip or spray irrigation. Process solutions are treated with bacteria concentrates in continuous or batch applications. This method may also enhance metal remineralization, reducing acid rock drainage and enhancing precious metal recovery to offset treatment costs.

Biotreatment of cyanide in spent ore and ore processing solutions begins by identifying bacteria that will grow in the waste source and that use the cyanide for normal cell building reactions. Native isolates are ideally adapted to the spent ore environment, the available nutrient pool, and potential toxic components of the heap environment. The cyanide-detoxifying bacteria are typically a small fraction of the overall population of cyanide-tolerant species.
For this reason, native bacteria isolates are extracted from the ore and tested for cyanide detoxification potential as individual species. Any natural detoxification potentials demonstrated in flask cyanide decomposition tests are preserved and submitted for bioaugmentation. Bioaugmentation of the cyanide detoxification population eliminates nonworking species of bacteria and enhances the natural detoxification potential by growth in waste infusions and chemically defined media. Pintail Systems Incorporated (PSI) maintains a bacterial library of some 2,500 strains of microorganisms and a database of their characteristics.

The working population of treatment bacteria is grown in spent ore infusion broths and process solutions to adapt to field operating conditions. The cyanide in the spent ore serves as the primary carbon or nitrogen source for bacteria nutrition. Other required trace nutrients are provided in the chemically defined broths. The bacterial consortium is then tested on spent ore in a 6-inch-by-10-foot column in the field or in the laboratory. The column simulates leach pile conditions, so that detoxification rates, process completion, and effluent quality can be verified. Following column



Spent Ore Bioremediation Process

tests, a field test may be conducted to verify column results.

The spent ore is remediated by first setting up a stage culturing system to establish working populations of cyanide-degrading bacteria at the mine site. Bacterial solutions are then applied directly to the heap using the same system originally designed to deliver cyanide solutions to the heap leach pads (see figure on previous page). Cyanide concentrations and leachable metals are then measured in heap leach solutions. This method of cyanide degradation in spent ore leach pads degrades cyanide more quickly than methods which treat only rinse solutions from the pad. In addition to cyanide degradation, biological treatment of heap leach pads has also shown significant biomineralization and reduction of leachable metals in heap leachate solutions.

WASTE APPLICABILITY:

The spent ore bioremediation process can be applied to treat cyanide contamination, spent ore heaps, waste rock dumps, mine tailings, and process water from gold and silver mining operations.

STATUS:

This technology was accepted into the SITE Demonstration Program in May 1994. A site located in Battle Mountain, Nevada has been selected for the demonstration. Preliminary treatability tests have been completed. In addition, PSI has completed two full-scale cyanide detoxification projects.

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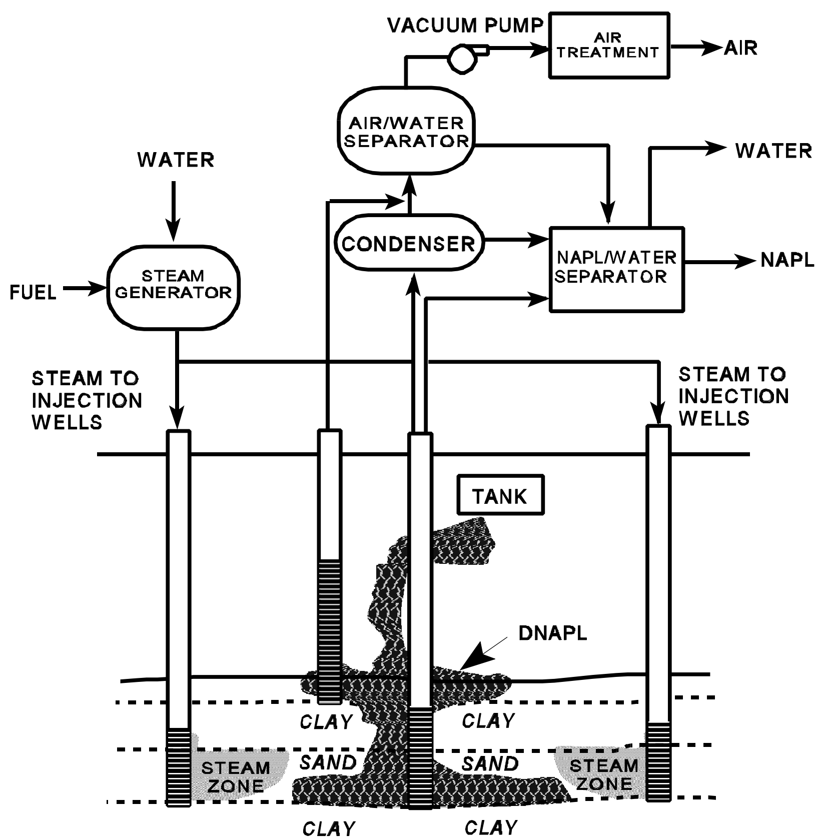
PRAXIS ENVIRONMENTAL TECHNOLOGIES, INC.
(In Situ Thermal Extraction Process)

TECHNOLOGY DESCRIPTION:

The in situ thermal extraction process heats soil with steam injection, enhancing pump-and-treat and soil vapor extraction processes used to treat volatile organic compounds (VOC) and semivolatile organic compounds (SVOC). This process is an effective and relatively inexpensive technique to raise a target soil volume to a nearly uniform temperature.

As illustrated in the figure below, steam is introduced to the soil through injection wells screened in contaminated intervals. The steam flow sweeps contaminants to extraction wells. Groundwater and liquid contaminants are pumped from the extraction wells; steam, air, and vaporized contaminants are extracted under vacuum. After the soil is heated by steam injection, the injection wells can introduce additional agents to facilitate the cleanup.

Recovered vapors pass through a condenser. The resulting condensate is combined with pumped liquids for processing in separation equipment. Separated nonaqueous phase liquids (NAPL) can be recycled or disposed of, and the water is treated prior to discharge. The noncondensible gases are directed to a vapor treatment system consisting of (1) catalytic oxidation equipment, (2) activated carbon filters, or (3) other applicable vapor technologies. The in situ thermal extraction process uses conventional injection, extraction and monitoring wells, off-the-shelf piping, steam generators, condensers, heat exchangers, separation



In Situ Thermal Extraction Process

equipment, vacuum pumps, and vapor emission control equipment.

WASTE APPLICABILITY:

The in situ thermal extraction process removes VOCs and SVOCs from contaminated soils and groundwater. The process primarily treats chlorinated solvents such as trichloroethene (TCE), tetrachloroethene (PCE), and dichloro-benzene; hydrocarbons such as gasoline, diesel, and jet fuel; and mixtures of these compounds.

The process can be applied to rapid cleanup of source areas such as dense NAPL pools below the water table surface, light NAPL pools floating on the water table surface, and NAPL contamination remaining after conventional pumping techniques. Subsurface conditions are amenable to biodegradation of residual contaminants, if necessary, after application of the thermal process. A cap is required for implementation of the process near the surface. For dense NAPL compounds in high concentrations, a barrier must be present or created to prevent downward percolation of the NAPLs. The process is applicable in less permeable soils with the use of novel delivery systems such as horizontal wells or fracturing.

STATUS:

This technology was accepted into the SITE Demonstration Program in August 1993. The demonstration is scheduled to occur at Hill Air Force Base (AFB) in Ogden, Utah. The Ogden Air Logistics Center Environmental Management Office and Armstrong Laboratory at Tyndall AFB, Florida are also participating in the demonstration.

From 1967 to 1979, unknown quantities of chlorinated solvents including TCE and PCE were disposed of in two unlined trenches at Hill AFB. These dense NAPL compounds migrated through the soil and shallow groundwater, pooling on top of a natural clay layer about 50 feet below the surface. The demonstration will be performed in this area, after most NAPLs have been recovered by conventional pumping.

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PROCESS TECHNOLOGIES, INC.
(Photolytic Destruction of Vapor-Phase Halogens)

TECHNOLOGY DESCRIPTION:

The proprietary, nonthermal technology developed by Process Technologies, Inc. (PTI), is a method of photochemically oxidizing gaseous organic compounds within a reaction chamber. PTI's Photolytic Destruction Technology (PDT) uses low-pressure ultraviolet (UV) lamps, with UV emissions primarily at wavelengths in the 185 to 254 nanometer range, located within the reaction chamber. Photons emitted from these lamps break apart the chemical bonds making up the volatile organic compound (VOC) molecule. The process is capable of destroying mixtures of chlorinated and nonchlorinated VOCs.

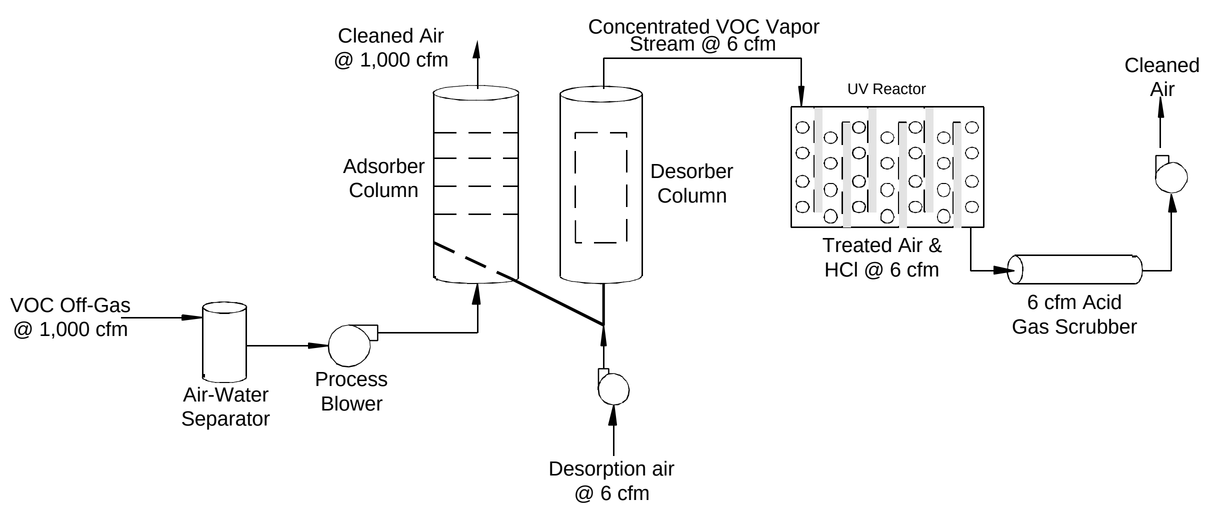
PTI uses a proprietary reagent that forms a liner within the process chamber. The reagent reacts chemically with the gaseous degradation products formed during the photolytic destruction of halocarbon molecules to form solid, stable reaction products.

Reagent lifetime depends on flow rate, influent concentrations, and specific chemical composition of destruction targets. PTI has performed tests on spent reagent to determine whether the material would be classified as a hazardous waste under the federal hazardous waste law and EPA regulations. Those tests indicated that the spent reagent is likely nontoxic. The spent reagent is also not reactive, corrosive, or flammable, and thus PTI is confident that it is not a hazardous waste under federal law. PTI accordingly believes that the spent reagent material can be disposed of as ordinary solid waste or used as a feedstock for cement manufacturing.

WASTE APPLICABILITY:

The technology was developed to destroy a number of families of compounds, including chlorinated solvents, chlorofluocarbons (CFCs), hydrochlorofluocarbons (HCFCs), and halons. Example sources of process off-gas include steam vapor extraction, tank vents, air strippers, steam strippers, and building vent systems.

The PDT system is designed and fabricated in 3- to 12-cubic-feet-per-minute (cfm) modules. The size of the module applied is dependent on the gas flow rate and VOC concentrations in the gas stream. The process is capable of destroying as high as 50,000 parts per million by volume (ppmv) VOC streams. PTI implements a fluid bed concentrator to allow for the treatment of high flow gas streams, or those with



Simplified Process Flow Diagram
of Photolytic Destruction

rates greater than 1,000 cfm. Significant cost savings can be realized if the gas flow can be reduced, and concentration increased prior to destruction.

The PTI process is simple in design and there are no moving parts. The system is capable of achieving greater than 90 percent on-line availability, inclusive of scheduled maintenance activities. The system is designed to run continuously, 24-hours per day.

STATUS:

The PTI technology was accepted into the SITE Demonstration Program in summer 1994. The demonstration began in September 1994 at McClellan Air Force Base (AFB) in Sacramento, California. The SITE demonstration was postponed shortly thereafter. Activities under the SITE Program will be rescheduled in 1997. Additional tests incorporating an improved design for treating soil vapor extraction off-gas were successfully completed at the AFB in January 1996.

PTI completed a successful 6-month treatability study at Hill AFB in Ogden, Utah. The purpose of the demonstration was to determine the effectiveness and commercial feasibility of the PDT in treating the high concentration, low flow, VOC-contaminated off-gases from the process tank vents in the facility. Process performance was compared directly to the standard treatment technology, granular activated carbon. A commercial system was installed in February 1996.

PTI completed a successful short-term, treatability study at Aerojet's Site 19F in May. Aerojet manufactures motors for liquid rockets and other defense-related equipment. This study was performed to evaluate the effectiveness and cost to remove and destroy trichloroethene (TCE) vapor from the existing extraction wells using the PDT. The results of this test showed that the PDT was able to destroy TCE at levels greater than 99 percent and at a cost less than activated carbon. PTI is now in discussions with Aerojet to supply the necessary equipment to remediate other known TCE plumes at the site.

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RECYCLING SCIENCES INTERNATIONAL, INC.
(Desorption and Vapor Extraction System)

TECHNOLOGY DESCRIPTION:

The mobile desorption and vapor extraction system (DAVES) uses a low-temperature fluidized bed to remove organic and volatile inorganic compounds from soils, sediments, and sludges. This system can treat materials with 85 percent solids at a rate of 10.5 tons per hour.

Contaminated materials are fed into a co-current, fluidized bed dryer, where they are mixed with hot air (about 1,000 to 1,400 °F) from a gas-fired heater. Direct contact between the waste material and the hot air forces water and contaminants from the waste into the gas stream at a relatively low fluidized-bed temperature (about 320 °F). The heated air, vaporized water and organics, and entrained particles flow out of the dryer to a gas treatment system.

The gas treatment system removes solid particles, vaporized water, and organic vapors from the air stream. A cyclone separator and baghouse remove most of the particulates. Vapors from the cyclone separator are cooled in a venturi scrubber, countercurrent washer, and chiller section before they are treated in a vapor-phase carbon adsorption system. The liquid residues from the system are centrifuged, filtered, and passed through two activated carbon beds arranged in series (see photograph below).

By-products from the DAVES include (1) treated, dry solid representing about 96 to 98 percent of solid waste feed, (2) a small quantity of centrifuge sludge containing organics, (3) a small quantity of spent adsorbent carbon, (4) wastewater that may need further treatment, and (5) small quantities of baghouse and cyclone dust that are recycled through the process.

The centrifuge sludge can be bioremediated, chemically degraded, or treated in another manner. Recycling Sciences International, Inc., has patented an electrochemical oxidation process (ECO) and is developing this process as an adjunct to the

Desorption and Vapor Extraction System (DAVES)

The SITE Program assesses but does not approve or endorse technologies.

DAVES. The ECO is designed to detoxify contaminants within the DAVES in a closed-loop system.

WASTE APPLICABILITY:

This technology removes from soil, sludge, and sediment volatile and semivolatile organics, including polychlorinated biphenyls (PCB), polynuclear aromatic hydrocarbons, pentachlorophenol, volatile inorganics (such as tetraethyl lead), and some pesticides. In general, the process treats waste containing less than 10 percent total organic contaminants and 30 to 95 percent solids. The presence of nonvolatile inorganic contaminants (such as metals) in the waste feed does not inhibit the process; however, these contaminants are not treated.

STATUS:

This technology was accepted into the SITE Program in April 1995. EPA is selecting a demonstration site for this process. Preferred demonstration wastes include harbor or river sediments containing at least 50 percent solids and contaminated with PCBs and other volatile or semivolatile organics. Soils with these characteristics may also be acceptable. About 300 tons of waste is needed for a 2-week test. Major test objectives are to evaluate feed handling, decontamination of solids, and treatment of gases generated by the process.

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RKK, LTD.
(CRYOCELL®)

TECHNOLOGY DESCRIPTION:

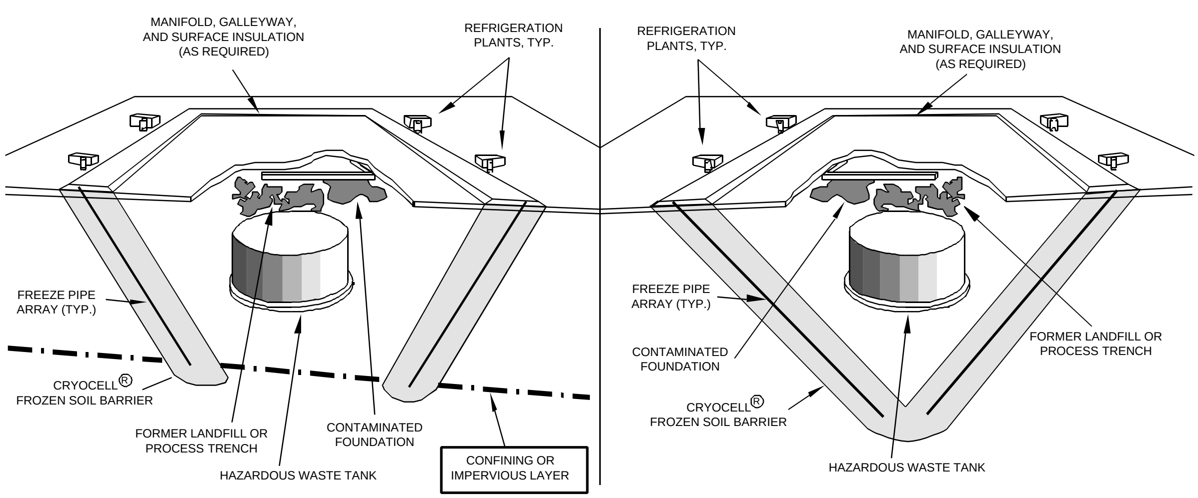
CRYOCELL® is a barrier system which provides real-time monitoring capability, earthquake resiliency, and diffusion-free full enclosure contaminant isolation. The system is repairable in situ and removable upon completion of containment needs.

CRYOCELL® design involves installing an array of freeze pipes, using standard well-drilling equipment, which surround the contaminated source or groundwater plume much like the ribs of a canoe. Once installed, the array of freeze pipes is connected to freeze plants by a distributive manifold and supplied with cooled brine at a design temperature of -10°C to -40°C to freeze the volume of soil between the pipes, resulting in a 12- to 16-foot barrier.

The barrier's thickness and temperature may be varied through design to match containment requirements. If no subsurface confining impervious layer is present, the array can be installed using an angled or "V"-shaped configuration beneath the contaminated zone, completely enclosing the site. If additional barrier thickness is a design requirement, a parallel array of freeze pipes is installed in staggered spacing outside the first array. This configuration allows the entire inner volume of soil between the two arrays to be frozen, thereby increasing barrier thickness per design up to 75 feet. The depth of the containment envelop can be in excess of 500 feet.

CRYOCELL® engineering is site-specific and considers many cost-related factors, including waste type, topography, soil conditions, thermal conductivity, and groundwater movement. A computer program incorporates all site characteristics into a three-dimensional model that engineers use to establish the most efficient design and estimate the cost of CRYOCELL® for a specific site.

A thick frozen soil barrier offers a number of advantages for confining hazardous waste. The barrier does not degrade or weaken over time and is repairable in situ. If ground movement fractures the barrier, the fissures can be filled and resealed quickly. Maintenance costs are extremely low, allowing continued use for extended periods. In addition, the frozen barrier is environmentally benign. When the site is decontaminated, the frozen soil is allowed to melt and the pipes are removed. The technique is an alternative to conventional



Schematic Diagram of CRYOCELL®

containment systems using steel, concrete, slurry walls, or grout curtains. The figure on the previous page illustrates two typical containment systems.

WASTE APPLICABILITY:

RKK, Ltd. (RKK), reports that CRYOCELL® can provide subsurface containment for a variety of sites and waste, including underground tanks; nuclear waste sites; plume control; burial trenches, pits, and ponds; in situ waste treatment areas; chemically-contaminated sites; and spent fuel storage ponds. CRYOCELL® is designed to contain all known biological, chemical, or radioactive contaminants. Frozen soil barriers are adaptable to any geometry; drilling technology presents the only constraint.

RKK reports that the technology can isolate sensitive areas within large active operations (for example, sites within chemical and nuclear facilities), smaller raw material and waste management units (for example, tank farms, burial trenches, and waste treatment lagoons), and operational chemically contaminated sites, such as chemical plants, refineries, and substations. The technology can also contain a site or contamination during an in situ remediation project. It can also provide a redundant barrier for cut-off contamination processes, and reduces flow of groundwater into a contaminated zone.

Contaminants are contained in situ, with frozen native soils serving as the containment medium. Frozen soil barriers are impervious to chemical attack and are virtually impermeable at subzero temperatures. In addition, frozen soil barriers have great inertia, so they can remain frozen for as long as two years without refrigeration.

CRYOCELL® is economically favorable for intermediate- and long-term containment at large sites, and maintenance costs are extremely low. CRYOCELL® generates no waste streams or residues.

STATUS:

This technology was accepted into the SITE Demonstration Program in summer 1994. A treatability study was completed at the Department of Energy's (DOE) Oak Ridge National Laboratory in 1995. Results from the study are documented in a DOE Innovative Technology Summary Report, titled *Frozen Soil Barrier Technology*, and, *Subsurface Contaminants Focus Area Technology Summary*, (DOE/EM-0296), August 1996.

The RKK technology is being considered by DOE for use at other hazardous waste sites. RKK receives academic, technical, and scientific support through a cooperative and licensing agreement with the University of Washington.

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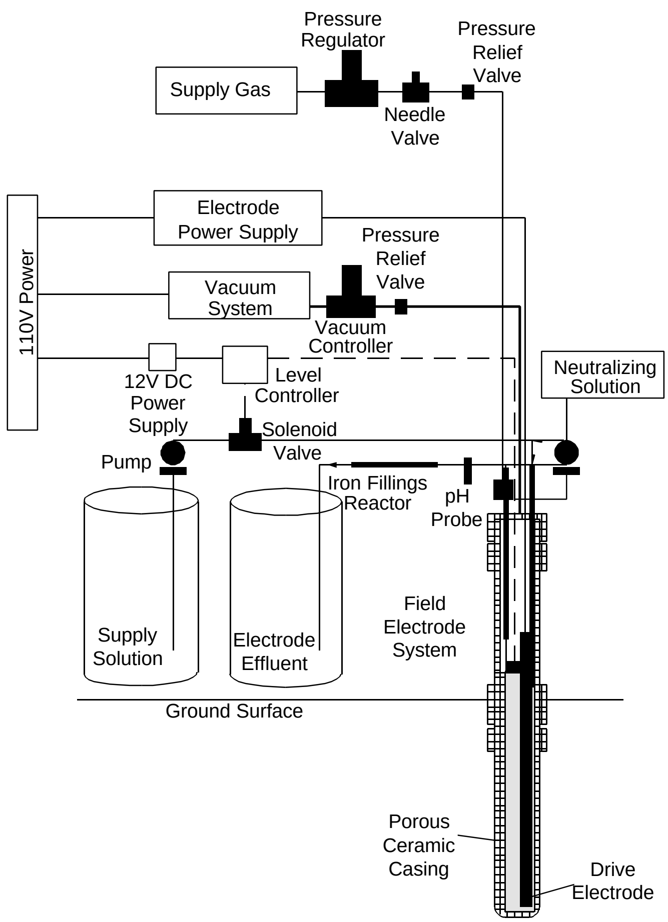
SANDIA NATIONAL LABORATORIES
(In Situ Electrokinetic Extraction System)

TECHNOLOGY DESCRIPTION:

Electrokinetic remediation has been used successfully to treat saturated soils contaminated with heavy metals. At some sites, however, it may not be desirable to add the quantities of water needed to saturate a contamination plume in the vadose zone. Sandia National Laboratories (SNL) has developed an electrokinetic remediation technology that can be used in unsaturated soils without adding significant amounts of water.

The SNL electrokinetic extraction system, shown in the figure below, consists of three main units: the electrode assembly (electrode casing and internal assemblies), the vacuum system, and the power supply. The electrode casing consists of a porous ceramic end that is 5 to 7 feet long and has an outer diameter of 3.5 inches. During field installation, the casing is attached to the required length of 3-inch polyvinyl chloride pipe. The electrode internal assembly consists of the drive electrode, a water level control system, and a pump system. The vacuum system consists of a venturi vacuum pump and vacuum regulator that together supply a constant vacuum for the electrode. Up to four 10,000-watt power supplies can operate in either constant voltage or constant current mode.

When the drive electrode is energized, contaminants and other ions are attracted into the electrode casing. The water level control system adds water to, and extracts water from, the electrodes. Water is supplied to the electrode from a supply solution tank



Schematic Diagram of the In Situ Electrokinetic Extraction System at the ground surface. This solution is either drawn into the electrode by the vacuum maintained in the electrode or by a supply pump. At the same time, water is continuously pumped out from the electrode casing at a constant rate. Part of the contaminated water is sent to an effluent waste tank at the ground surface; the remainder is returned to the electrode to maintain circulation of the fluid surrounding the electrode. A metering pump controlled by in-line pH meters regulates the introduction of neutralization chemicals to each electrode. Process control and monitoring equipment is contained in a 10-foot- by-40-foot instrument trailer.

WASTE APPLICABILITY:

SNL has developed its electrokinetic extraction system to treat anionic heavy metals such as chromate in unsaturated soil. There is no lower limit to the contaminant concentration that can be treated; however, there may be a lower limit on the ratio of contaminant ions to other ions in the soil.

The technology can be expanded to treat saturated soils. Soil that is highly conductive because of a high salinity content is not suitable for this technology. In addition, sites with buried metal debris, such as pipelines, are not appropriate.

STATUS:

This technology was accepted into the SITE Demonstration Program in summer 1994. The SITE demonstration began May 1996, at an unlined chromic acid pit within a SNL landfill. The demonstration is scheduled for completion in January 1997.

Recent bench-scale studies at SNL have shown the technology to be effective in sandy soils with a moisture content as low as 7 percent. Field testing is underway to characterize in situ electrokinetic extraction of chromate contamination from unsaturated soils at the SNL chemical waste landfill. These tests are intended to show the technology's effectiveness in achieving in situ water control in unsaturated soil and to track the movement of chromate contamination.

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SELENTEC ENVIRONMENTAL TECHNOLOGIES, INC.
(Selentec MAG*SEP℠ Technology)

TECHNOLOGY DESCRIPTION:

The MAG*SEP℠ process uses the principles of chemical adsorption and magnetism to selectively bind and remove heavy metals or radionuclides from aqueous solutions (groundwater, wastewater, drinking water). The contaminants are adsorbed on specially formulated particles which have a core made from magnetic material; these particles are then separated (along with the adsorbed contaminants) from the solution using a magnetic filter or magnetic collector. The magnetic core has no interaction with the contaminant.

The proprietary adsorbing particles are made of a composite of organic polymers and magnetite. The particles can be manufactured in two forms: one with an ion exchanger and/or chelating functional group attached to the particle surface (amidoxime functionalized resin), or one with inorganic adsorbers bound to the surface of the particles (clinoptilolite). These particles have high surface areas and rapid adsorption kinetics.

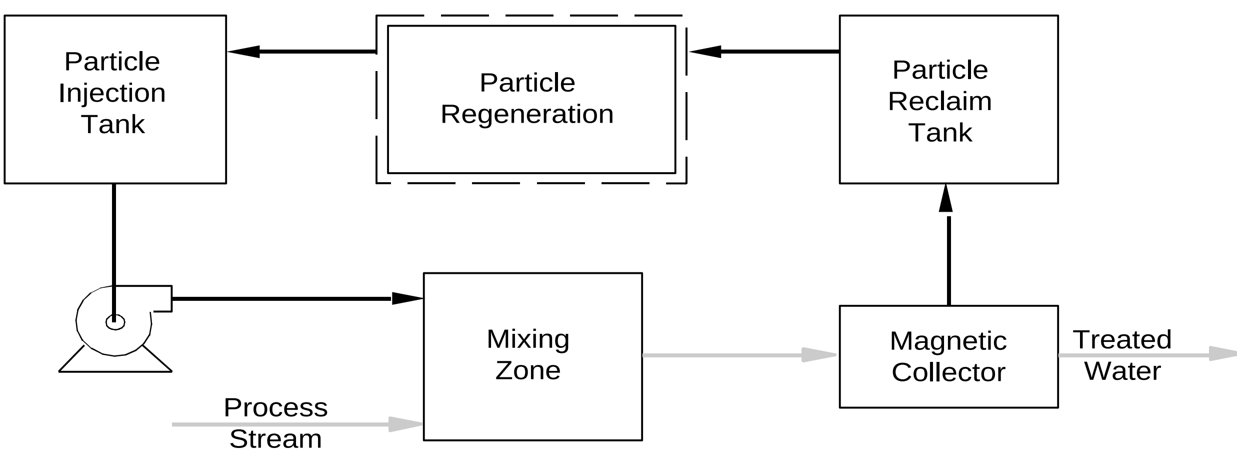
A typical MAG*SEP℠ treatment system consists of:

- a particle contact zone
- particle handling system, including particle injection components, a magnetic separator, and particle reclaim components
- particle regeneration system (where applicable)

The process stream enters a contact zone (usually a tank - other configurations are used for particular applications) where MAG*SEP℠ particles are injected and mixed. The contact zone provides the necessary solution flow characteristics and contact time with the particles to ensure that the contamination will be adsorbed onto the active surface sites of the particles. The mixture then flows through a magnetic collector, where the contaminated particles are retained while the treated process stream passes through.

Depending on the application, type of particle, and contaminant concentration, the particles may be re-injected into the flow stream, collected and disposed of, or regenerated and reused. The regeneration solution is processed to recover (concentrate and remove) the contaminants and may be recycled.

The MAG*SEP℠ process is able to selectively remove (either ex situ or in situ) the following contaminants from aqueous solutions: titanium, copper, cadmium, arsenic, cobalt, molybdenum, platinum, selenium, chromium, zinc, gold, iodine, manganese, technetium, mercury, strontium, iron, ruthenium, thallium, cesium, cobalt, palladium, lead, radium, nickel, silver, bismuth, thallium, antimony, zirconium, radium, cerium, and all actinides. The process operates at flow rates up to 2000 gallons per minute (gpm).



Schematic Diagram of the Mag*SEP℠ Treatment System

WASTE APPLICABILITY:

The MAG*SEP^{SM} technology reduces heavy metal and radionuclide contamination in water and wastewater. The technology has specific applications in environmental remediation and restoration, treatment of acid mine drainage, resource recovery, and treatment of commercial industrial wastewater. MAG*SEP^{SM} particles can be produced to incorporate any known ion exchanger or sorbing material. Therefore, MAG*SEP^{SM} can be applied in any situation where conventional ion exchange is used.

STATUS:

The MAG*SEP^{SM} technology was accepted into the SITE Program in 1996 and is also one of 10 technologies participating in the Rapid Commercialization Initiative (RCI). RCI was created by the Department of Commerce, Department of Defense, Department of Energy, and EPA to assist in the integration of innovative technologies into the marketplace.

Selentec Environmental Technologies, Inc., is currently working under an agreement with Argonne National Laboratory to demonstrate the MAG*SEP^{SM} technology at the U.S. Department of Energy's Savannah River Site. At Savannah River, the technology is being used to reduce the heavy metal concentration in coal pile runoff water. Analytical data from the demonstration has shown that contaminant levels can be reduced to drinking water standards.

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SEVENSON ENVIRONMENTAL SERVICES, INC.
(MAECTITE® Chemical Treatment Process)

TECHNOLOGY DESCRIPTION:

The patented MAECTITE® chemical treatment process for lead and other heavy metals uses reagents and processing equipment to render soils, waste, and other materials nonhazardous when tested by the Resource Conservation and Recovery Act toxicity characteristic leaching procedure (TCLP). The MAECTITE® process reduces leachable lead, hexavalent chromium, and other heavy metals to below treatment standards required by land-ban regulations (September 19, 1994 40 CFR Parts 268, Final Rule). Lead in treated material, as determined by approved EPA methods in SW-846 (such as the TCLP, extraction procedure toxicity test, and the multiple extraction procedure), complies with limits established by EPA. The photograph below shows a 500-ton-per-day unit.

500-Ton-Per-Day MAECTITE®
Processing System

Chemical treatment by the MAECTITE® process converts leachable lead into insoluble minerals and mixed mineral forms within the material or waste matrix. MAECTITE® reagents stimulate the nucleation of crystals by chemical bonding to yield mineral compounds in molecular forms. These forms are resistant to leaching and physical degradation from environmental forces. The durability of traditional monolithic solidification-stabilization process end-products is often measured by geotechnical tests such as wet-dry, freeze-thaw, permeability, and unconfined compressive strength. The MAECTITE® process does not use physical binders, is not pozzolanic or siliceous, and does not rely on the formation of metallic hydroxides using hydration mechanisms. Therefore, these tests are not relevant to MAECTITE® product chemical stability, although engineered properties are readily obtained, if required. MAECTITE® is not pH dependent and does not use adsorption, absorption, entrapment, lattice containment, encapsulation, or other physical binding principles. The technology is a true chemical reaction process that alters the structure and properties of the waste, yielding stable compounds.

The MAECTITE® process uses water to assist in dispersing reagents. However, the dehydration characteristic of the process liberates water present in waste prior to treatment (absorbed and hydrated forms) to a free state where it can be removed from the waste matrix by evaporation and capillary drying principles. The ability of treated material to readily lose water, the formation of dense mineral crystals, and the restructuring of the material as a result of MAECTITE® treatment (where interstitial space is minimized), all contribute to reduced waste volume and weight.

Ex situ MAECTITE® processing equipment generally consists of material screening and sizing components, liquid and solid reagent storage delivery subsystems, and a mixing unit such as a pug mill. Equipment is mobile but can be modified for fixed system operations. In situ MAECTITE® processing equipment is also available; system selection is largely dictated by contaminant plume configuration, soil characteristics, and site space limitations.

WASTE APPLICABILITY:

Materials that have been rendered nonhazardous include soils; sludges; sediments; battery contents, including casings; and foundry sands. Oversized material can be treated with the process as debris, but size reduction often makes processing more efficient. Even sludges with free liquids (as determined by the paint filter test) have been treated to TCLP compliance when excess fluids are present.

The range of lead levels effectively treated has not been fully determined; however, soils with total lead as high as 30 percent (by weight) and TCLP values over 15,000 milligrams per liter (mg/L) were not problematic. Common lead levels encountered have averaged from 200 milligrams per kilogram (mg/kg) to 6,500 mg/kg with TCLP averaging 20 to 400 mg/L. Material geochemistry most often dictates final MAECTITE® treatment designs. Furthermore, correlations between total lead and regulated leachable lead levels are inconsistent, with treatment efforts more strongly related to the geochemical characteristics of the waste material.

STATUS:

The chemical treatment technology was initially accepted into the SITE Demonstration Program in March 1992. EPA is seeking a suitable demonstration site.

Sevenson Environmental Services, Inc. (Sevenson), acquired the MAECTITE® technology in 1993 and was issued second and third patents in 1995 and 1996, respectively. Combining ex situ and in situ quantities, over 400,000 tons of material has been successfully processed. Treatability studies have been conducted on over 100 different materials in over 40 states, Canada, Italy, and Mexico. The technology has been applied at full-scale demonstration and remedial projects in over 20 states and in all 10 EPA regions.

The MAECTITE® process has been formally accepted into the EPA PQOPS program for the fixation-stabilization of inorganic species. Proprietary technology modifications have shown promise in rendering radionuclides nonleachable using gamma spectral counting methods on TCLP extract. Sevenson is treating 30,000 cubic yards of radioactive-contaminated material using their proprietary technology modifications.

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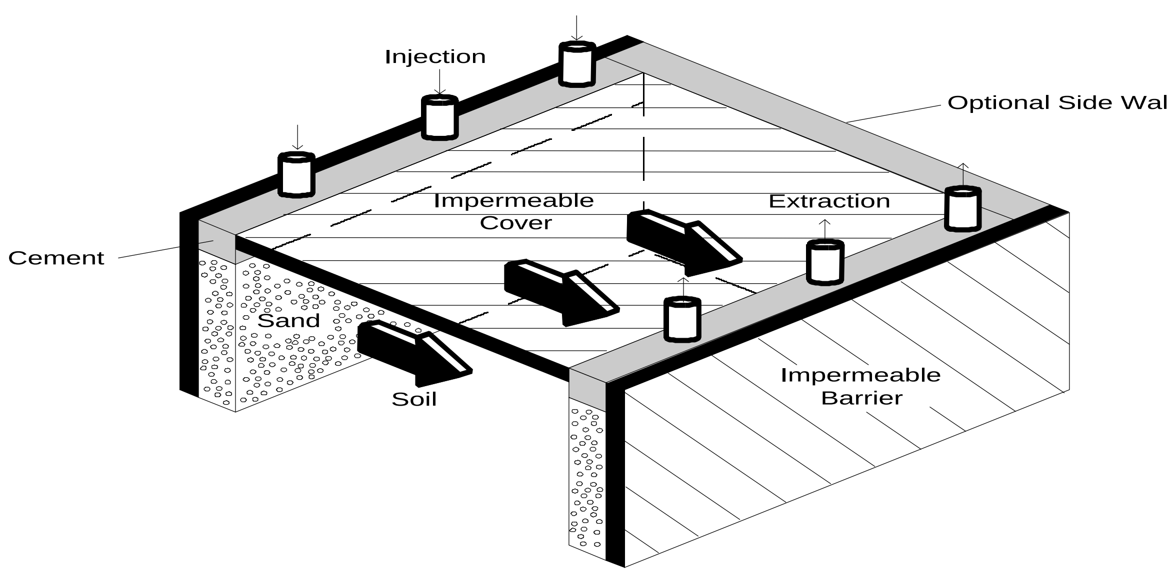
SIVE SERVICES
(Steam Injection and Vacuum Extraction)

TECHNOLOGY DESCRIPTION:

Steam Injection and Vacuum Extraction (SIVE) uses steam injection wells in conjunction with dual-phase extraction wells for in situ treatment of contaminated soil and groundwater. The injected steam strips volatile and semivolatile organic compounds as it flows through the contaminated zones. The steam increases the subsurface temperature, which increases mass transfer and phase exchange rates, reduces liquid viscosities, and accelerates desorption of contaminants from the matrix. The moisture and warmth provided by the steam also accelerates biodegradation of residual contaminants. As a result, contaminants are extracted or degraded at increased rates as compared to conventional isothermal vapor and liquid extraction systems.

SIVE-LF (Linear Flow) is an enhanced SIVE method designed for relatively shallow depths. With the SIVE-LF process, as illustrated in the figure below, steam is forced to flow horizontally and uniformly from one trench, through the contaminant zone, and into another trench from which the contaminants are extracted. The large open area of the trench faces allow for high injection and extraction rates, which promote low treatment duration. The trenches also allow for installation of an impermeable barrier, such as a polyethylene liner, against one face of the open trench before the trench is backfilled, thus reducing the flow of injected or extracted fluid outside the area of the targeted zones. A surface covering for the treatment area prevents short-circuiting of the flow of injected steam to the atmosphere, and prevents atmospheric air from entering the extraction trench.

Surface equipment for SIVE includes conventional steam generation and delivery systems, and the vacuum extraction system. The vacuum extraction system includes a vacuum blower, steam condenser, other cooling components, and air emission control devices. The condensate generated by the process requires further treatment or off-site disposal. The reliability of the equipment and automatic controls



The SIVE-LF Process

allow SIVE to operate without constant direct supervision.

WASTE APPLICABILITY:

SIVE may be applied to sites that have soil or groundwater contaminated with fuels, industrial solvents, oils, and other liquid toxics, and may be applied at any depth. The SIVE-LF process is designed to treat to depths of 30 feet. Because highly volatile contaminants are readily air-stripped without the added effects of steam, the steam-stripping effect will be greatest on the heavier, less volatile contaminants. SIVE also effectively removes floating non-aqueous phase liquids from groundwater.

STATUS:

This technology was accepted into the SITE Demonstration Program in summer 1994. A suitable site for the demonstration is being sought.

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SOLUCORP INDUSTRIES
(Molecular Bonding System®)

TECHNOLOGY DESCRIPTION:

The Molecular Bonding System® (MBS) is a process developed for the stabilization of a variety of media, such as soil, sludge, slag, and ash, that is contaminated with heavy metals. The process employs a proprietary mixture of nonhazardous chemicals to convert the heavy metal contaminants from their existing reactive and leachable forms (usually oxides) into insoluble, stable, nonhazardous, metallic-sulfide compounds that will achieve toxicity characteristic leaching procedure (TCLP) levels far below regulatory limits. The MBS process maintains the pH levels in the media within the range where the insolubility of the heavy metal sulfides is assured. The system also provides buffer capacity to ensure that the pH is not significantly altered by the addition of acids or caustics to the media.

As depicted in the diagram below, the MBS treatment process is completely mobile and easily transportable (to allow for on-site treatment). Waste material is screened and crushed as required to reduce particle sizes to an average 1-inch diameter (particle size reduction increases surface area, which maximizes contact with the reagents). The waste media is then mixed with powdered reagents in a closed-hopper pug mill (the reagent mixture is established through treatability studies for the site-specific conditions). Water is then added to catalyze the reaction and to ensure homogeneous mixing. There is no curing time and the resulting increase in volume is between 2 to 3 percent. The treated media is then conveyed to a stockpile where it can then be either returned to the original site or disposed in a landfill as cover, fill, or contour material.

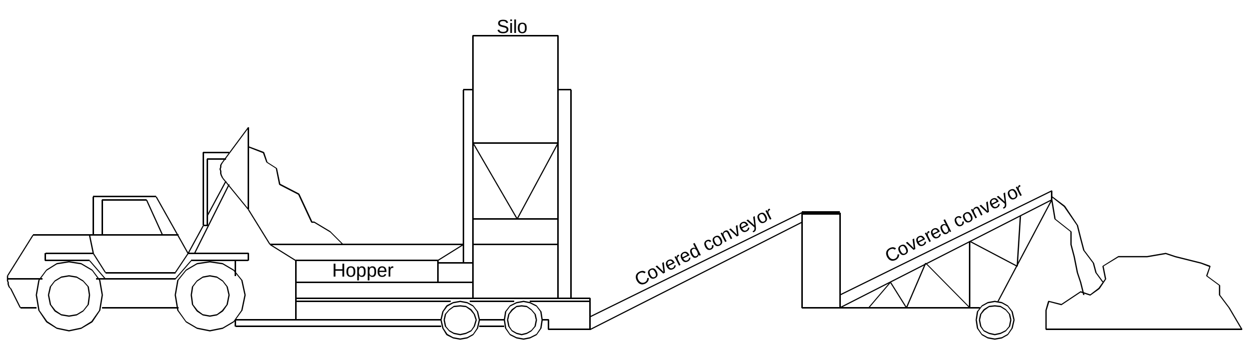
MBS can also be applied with traditional in situ mixing techniques such as tillers, eliminating the need for excavating and preparing the soil.

The MBS process can also be used to stabilize waste "in line" during the manufacturing process, preventing the waste from being classified as hazardous. Commercial applications on slag from a secondary smelter are underway.

WASTE APPLICABILITY:

The MBS process stabilizes heavy metals in soil, sludges, baghouse dust, ash, slag, and sediment. Heavy metals rendered inert by the process include arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. The process can simultaneously stabilize multiple heavy metal contaminants. The presence of organics does not affect treatment by MBS.

STATUS:



Process Flow Diagram of the Molecular Bonding System

This technology was accepted into the SITE Demonstration Program in early 1995. A suitable demonstration site is being selected. The MBS process has undergone extensive bench-scale and pilot-scale testing prior to its successful full-scale commercialization. The same reductions in the TCLP levels of hazardous contaminants achieved in the laboratory were achieved at five manufacturing sites in five different states.

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U.S. AIR FORCE
(Phytoremediation of TCE-Contaminated Shallow Groundwater)

TECHNOLOGY DESCRIPTION:

The U. S. Air Force (USAF) has initiated a field demonstration designed to evaluate the effectiveness of eastern cottonwood trees in remediating shallow groundwater contaminated with trichloroethene (TCE). Using vegetation to remediate contaminated soil and groundwater is known as phytoremediation.

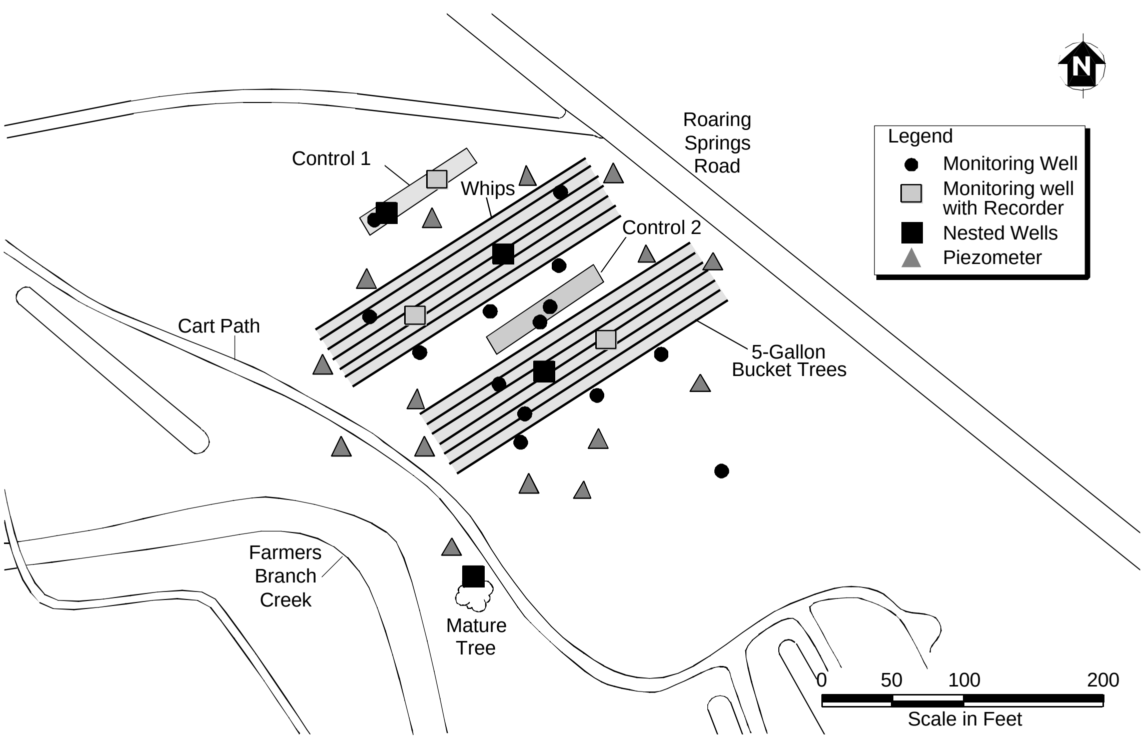
Phytoremediation of groundwater involves planting deep-rooted, water-loving vegetation to reduce contaminant levels in the saturated zone. The USAF's demonstration entails planting and cultivating eastern cottonwood trees over a dissolved TCE plume in a shallow (6 to 11 feet below grade) alluvial aquifer.

The cottonwood trees are expected to bioremediate the contaminated groundwater and any contaminated soil through one or more of the following mechanisms:

- Release of root exudates and enzymes stimulating microbial activity in the rhizosphere and enhancing biochemical transformations of contaminants
- Metabolism or mineralization of contaminants within the vegetative tissues; the contaminated water enters the vegetative tissues by root uptake from the aquifer
- Transpiration of water by the leaves

In essence, the trees are expected to serve as a natural pump-and-treat system.

TCE concentrations in the groundwater, soil from the rhizosphere, and tree tissues will be monitored during the demonstration. In general,



Schematic Diagram of the Site Layout at Naval Air Station Ft. Worth data will be gathered and interpreted to identify the overall effect of the planted trees on the dissolved TCE plume in the aquifer. Groundwater levels and TCE concentrations in the aquifer will be measured initially to establish baseline conditions and subsequently to map changes in the aquifer throughout the demonstration period. Changes in the flow field and the position of the TCE plume will also be modeled.

TCE concentrations will also be monitored in the soil from the rhizosphere and in the tree tissues. Ratios of daughter and parent compounds will be calculated for groundwater, soil, and tissue samples collected throughout the demonstration period. Microbial activity in the rhizosphere will be monitored and transpiration rates will be measured. These data will be used to determine the fate of the TCE at the site, including those processes that affect its fate.

WASTE APPLICABILITY:

The USAF's phytoremediation technology may be used to remediate shallow groundwater and soil contaminated with TCE, as well as other contaminants common to USAF installations. Such contaminants include petroleum, munitions, and halogenated hydrocarbons. Costs of the technology are limited to initial site preparation, planting, and occasional maintenance (irrigation).

STATUS:

The technology was accepted into the SITE Demonstration Program in 1996. The USAF is currently demonstrating its phytoremediation technology on a TCE plume near Air Force Plant 4 at the Naval Air Station Ft. Worth, formerly Carswell Air Force Base in Fort Worth, Texas. Initial site characterization and final site selection were completed in January 1996. Site development, which included planting trees and installing the irrigation system, was completed in April 1996. The figure on the previous page details the layout of the site. Baseline sampling began in June 1996, and demonstration sampling is scheduled to continue until 2000. The USAF speculates that the trees may begin transpiring water from the aquifer as early as the summer of 1997.

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VORTEC CORPORATION
(Oxidation and Vitrification Process)

TECHNOLOGY DESCRIPTION:

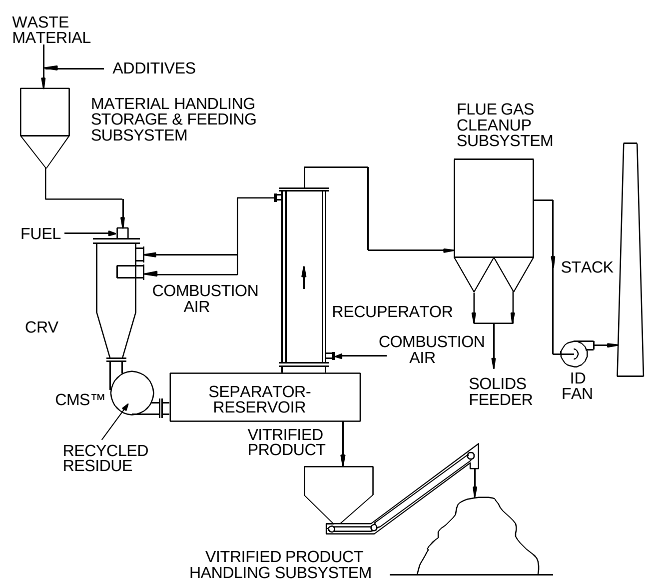
Vortec Corporation (Vortec) has developed an oxidation and vitrification process for remediating soils, sediments, sludges, and mill tailings contaminated with organics, inorganics, and heavy metals. The process can oxidize and vitrify materials introduced as dry granulated materials or slurries.

The figure below illustrates the Vortec oxidation and vitrification process. Its basic elements include (1) a cyclone melting system (CMS™); (2) a material handling, storage, and feeding subsystem; (3) a vitrified product separation and reservoir assembly; (4) a waste heat recovery air preheater (recuperator); (5) an air pollution control subsystem; and (6) a vitrified product handling subsystem.

The Vortec CMS™ is the primary thermal processing system and consists of two major assemblies: a counterrotating vortex (CRV) in-flight suspension preheater and a cyclone melter. First, slurried or dry-contaminated soil is introduced into the CRV. The CRV (1) uses the auxiliary fuel introduced directly into the CRV; (2) preheats the suspended waste materials along with any glass-forming additives mixed with oil; and (3) oxidizes any organic constituents in the soil. The average temperature of materials leaving the CRV combustion chamber is between 2,200 and 2,800 °F, depending on the melting characteristics of the processed soils.

The preheated solid materials exit the CRV and enter the cyclone melter, where they are dispersed to the chamber walls to form a molten glass product. The vitrified, molten glass product and the exhaust gases exit the cyclone melter through a tangential exit channel and enter a glass- and gas-separation chamber.

The exhaust gases then enter an air preheater for waste heat recovery and are subsequently delivered to the air pollution control subsystem for particulate and acid gas removal. The molten glass product exits the glass- and gas-separation chamber through the tap and is delivered to a water quench assembly for subsequent disposal.



Vortec Oxidation and Vitrification Process

Unique features of the Vortec oxidation and vitrification process include the following:

- Processes solid waste contaminated with both organic and heavy metal contaminants
- Uses various fuels, including gas, oil, coal, and waste
- Handles waste quantities ranging from 5 tons per day to more than 400 tons per day
- Recycles particulate residue collected in the air pollution control subsystem into the CMS™. These recycled materials are incorporated into the glass product, resulting in zero solid waste discharge.
- Produces a vitrified product that is nontoxic according to EPA toxicity characteristic leaching procedure (TCLP) standards. The product also immobilizes heavy metals and has long- term stability.

WASTE APPLICABILITY:

The Vortec oxidation and vitrification process treats soils, sediments, sludges, and mill tailings containing organic, inorganic, and heavy metal contamination. Organic materials included with the waste are successfully oxidized by the high temperatures in the CRV. The inorganic constituents in the waste material determine the amount and type of glass-forming additives required to produce a vitrified product. This process can be modified to produce a glass cullet that consistently meets TCLP requirements.

STATUS:

The Vortec oxidation and vitrification process was accepted into the SITE Emerging Technology Program in May 1991. Research under the Emerging Technology Program was completed in winter 1994, and Vortec was invited to participate in the SITE Demonstration Program.

Construction of a 25-ton-per-day, transportable system for treating contaminated soil at a Department of Energy site in Paducah, Kentucky was initiated in October 1996. The demonstration is scheduled to begin in 1997.

A 50-ton-per-day system has been purchased by Ormet Aluminum Corporation of Wheeling, West Virginia for recycling aluminum spent pot liners, a cyanide- and fluoride-containing waste (K088). The recycling system became operational in 1996.

Vortec is offering commercial systems and licenses for the CMS™ system.

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WESTERN RESEARCH INSTITUTE
(Contained Recovery of Oily Wastes)

TECHNOLOGY DESCRIPTION:

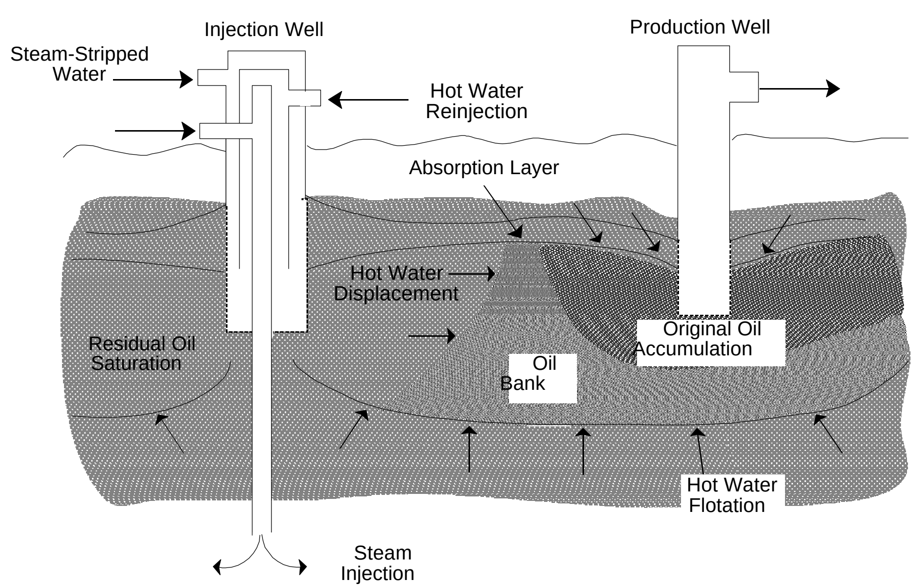
The contained recovery of oily wastes (CROW®) process recovers oily wastes from the ground by adapting a technology used for secondary petroleum recovery and primary production of heavy oil and tar sand bitumen. Steam or hot water displacement moves accumulated oily wastes and water to production wells for aboveground treatment.

Injection and production wells are first installed in soil contaminated with oily wastes (see figure below). If contamination has penetrated into or below the aquifer, low-quality steam can be injected below the organic liquids to dislodge and sweep them upward into the more permeable aquifer soil regions. Hot water is injected above the impermeable regions to heat and mobilize the oily waste accumulation. The mobilized wastes are then recovered by hot water displacement.

When the organic wastes are displaced, organic liquid saturation in the subsurface pore space increases, forming a free-fluid bank. The hot water injection displaces the free-fluid bank to the production well. Behind the free-fluid bank, the contaminant saturation is reduced to an immobile residual saturation in the subsurface pore space. The extracted contaminant and water are treated for reuse or discharge.

During treatment, all mobilized organic liquids and water-soluble contaminants are contained within the original boundaries of waste accumulation. Hazardous materials are contained laterally by groundwater isolation and vertically by organic liquid flotation. Excess water is treated in compliance with discharge regulations.

The CROW® process removes large portions of contaminant accumulations; stops the downward and lateral migration of organic contaminants; immobilizes any remaining organic wastes as a residual saturation; and reduces the volume, mobility, and toxicity of the contaminants. The process can be used for shallow and deep areas, and can recover light and dense nonaqueous phase liquids. The system uses readily available mobile



CROW® Subsurface Development

equipment. Contaminant removal can be increased by adding small quantities of selected biodegradable chemicals in the hot water injection.

In situ biological treatment may follow the displacement, which continues until groundwater contaminants are no longer detected in water samples from the site.

WASTE APPLICABILITY:

The CROW® process can be applied to manufactured gas plant sites, wood-treating sites, petroleum-refining facilities, and other areas with soils and aquifers containing light to dense organic liquids such as coal tars, pentachlorophenol (PCP) solutions, chlorinated solvents, creosote, and petroleum by-products. Depth to the contamination is not a limiting factor.

STATUS:

The CROW® process was tested in the laboratory and at the pilot-scale level under the SITE Emerging Technology Program (ETP). The process demonstrated the effectiveness of hot water displacement and the benefits of including chemicals with the hot water. Based on results from the ETP, the CROW® process was invited to participate in the SITE Demonstration Program. The process was demonstrated at the Pennsylvania Power and Light (PP&L) Brodhead Creek Superfund site at Stroudsburg, Pennsylvania. The site contained an area with high concentrations of by-products from past operations. The demonstration began in July 1995; field work was completed in June 1996. Follow-up sampling is planned for early 1997. The Innovative Technology Evaluation Report will be available from EPA in 1998.

Sponsors for this program, in addition to EPA and PP&L, are the Gas Research Institute, the Electric Power Research Institute, and the U.S. Department of Energy. Remediation Technologies, Inc., assisted Western Research Institute with the demonstration.

Also, a pilot-scale demonstration was completed at a wood treatment site in Minnesota. Over 80 percent of nonaqueous phase liquids were removed in the pilot test, as predicted by treatability studies, and PCP concentrations decreased 500 percent. The full-scale remediation for this site is underway. Early results show an organic removal rate an order-of-magnitude greater than conventional pump-and-treat processes. Several other sites are being evaluated.

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WHEELABRATOR TECHNOLOGIES INC.
(WES-PHix® Stabilization Process)

TECHNOLOGY DESCRIPTION:

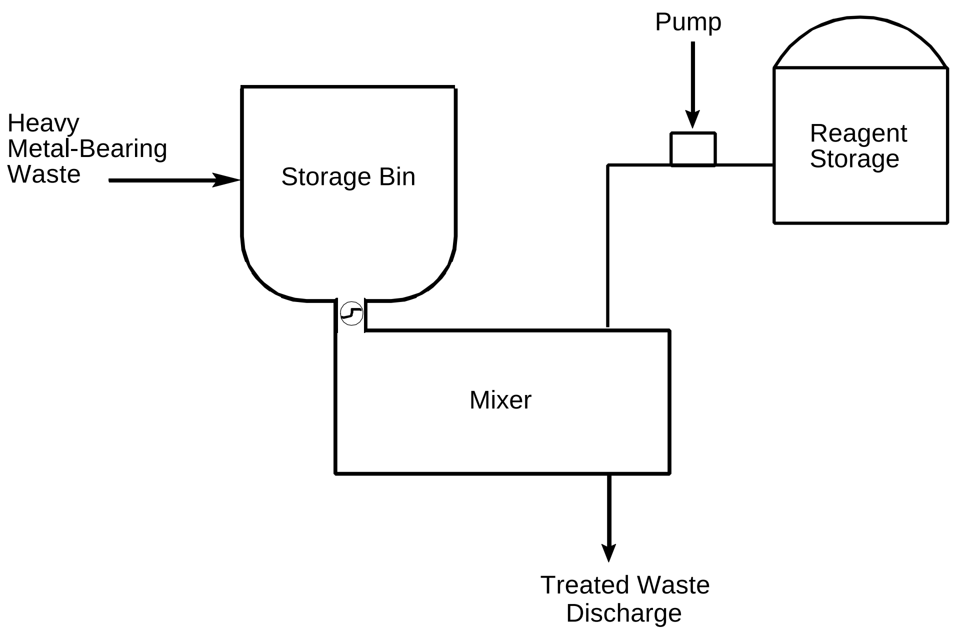
WES-PHix® is a patented stabilization process that significantly reduces the solubility of certain heavy metals in solid waste streams by altering the chemical composition of the waste material. The process does not produce a solidified mass, unlike most other stabilization technologies.

The figure below illustrates the process. First, waste is fed at a controlled rate into a mixing device, such as a pug mill. The full-scale WES-PHix® process uses a pug mill with a capacity of 40 to 200 tons per hour. The stabilization reagent is then added to and mixed with the waste for about 1 minute. Once stabilized, the waste is removed by a conveyor from the end of the mixer. For some wastes containing cadmium, small amounts of lime must also be added. The WES-PHix® Process uses a proprietary form of soluble phosphate to form insoluble and highly stable metal phosphate minerals. Reaction kinetics are rapid; thus, no curing step is necessary. As a result, metal concentrations in the treated waste are less than toxicity characteristic leaching procedure (TCLP) regulatory limits. In addition, the use of small quantities of liquid phosphate reagent creates only a minimal increase in the weight of the stabilized waste.

Equipment requirements include a metering device for feeding the waste stream to the mixer, and a storage tank for the liquid reagent. Over-sized items such as boulders or wood debris require crushing or removal by screens before treatment. No posttreatment is necessary with this process. Treated residuals can be transported for final disposal with dump trucks or roll-off container vehicles.

WASTE APPLICABILITY:

This process was originally developed to treat municipal waste combustion ash containing heavy metals. The commercial-scale process has treated over 7 million tons of ash. However, laboratory treatability data indicate that the technology can also treat contaminated soils, slags, sludges, foundry sands, and baghouse dusts. Recent research indicates that the process is particularly effective at stabilizing lead, cadmium, copper, and zinc in a



WES-PHix® Stabilization Process

variety of media, as measured by TCLP and other laboratory leaching tests.

STATUS:

The WES-PHix® process was accepted into the SITE Demonstration Program in spring 1993. The demonstration, which was scheduled to occur at the Jack's Creek site in Maitland, Pennsylvania, has been postponed.

FOR FURTHER INFORMATION:

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